

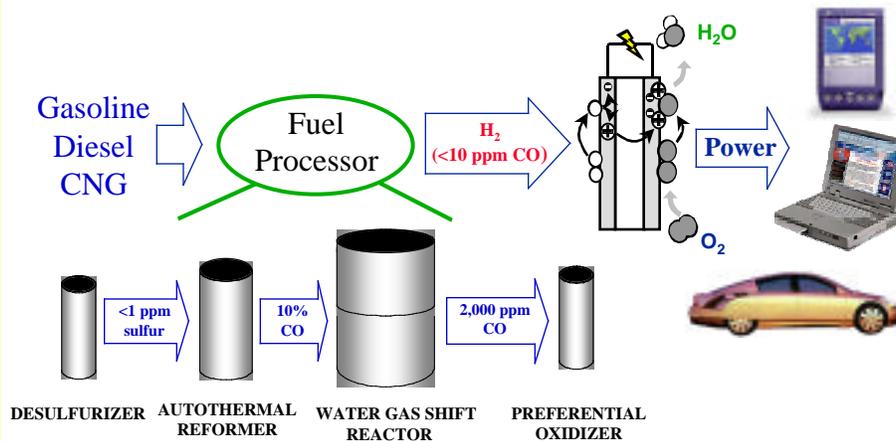
Microsystem-Based Fuel Processors

Contractor: University of Michigan
Subcontractors: Hydrogen Burner Tech. (CA)
MesoSystems, Inc. (WA)
Ricardo, Inc. (MI)

Project Duration: 4 years
Estimated Funding: \$5,937,184
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Technical Approach



Technical Approach

Microchannel
system

Higher activity
catalysts

-Complexation
sulfur adsorbents

High efficiency
microcombustor/-vaporizer

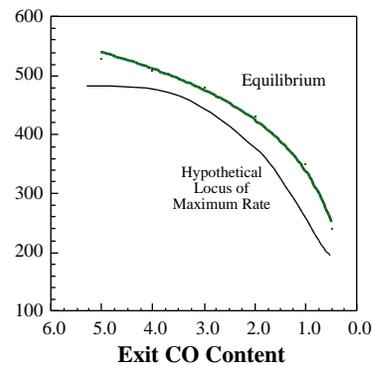
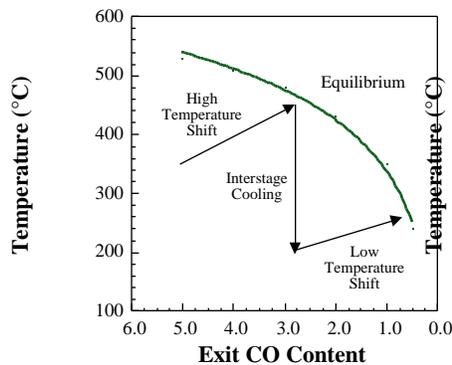


Fuel processor
that meets or
exceeds
DoE targets



Microchannel Systems

(1) Active cooling

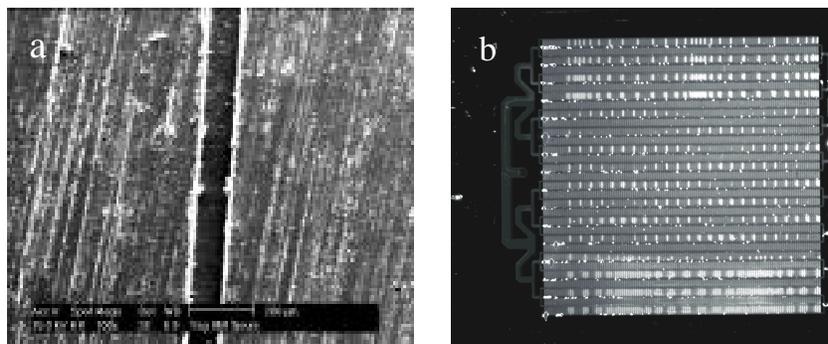


Microchannel Systems

- (1) Active cooling
- (2) Reduced heat and mass transport resistances
- (3) More efficient thermal coupling
- (4) Better cold start and transient responses



Microchannel Systems

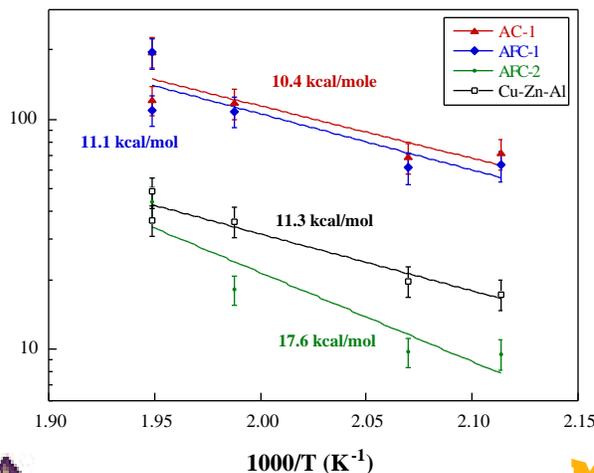


Microchannels produced in (a) aluminum and (b) silicon blocks.
Microchannel in the aluminum block is 125 μm diameter.



High Activity Shift Catalysts: $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$

CO Consumption Rate (mmol/g·sec)



H₂O:CO=5.6
Dry gas=8.4% CO in H₂
GHSV 25,000 hr⁻¹



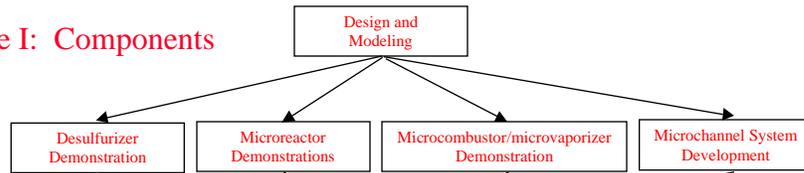
Technical Goals and Objectives

- (1) Demonstrate high performance desulfurizer, catalysts, microreactor and microcombustor/-vaporizer concepts
- (2) Design, fabricate and evaluate a 1 kW fuel-flexible (including EPA Phase II reformulated gasoline) fuel processor
- (3) Design, fabricate and evaluate up to a 25 kW fuel-flexible (including EPA Phase II reformulated gasoline) fuel processor

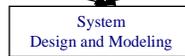


Summary of Work Plan

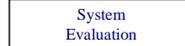
Phase I: Components



Phase II: 1 kW Processor



Phase III: 25 kW Processor



Major Tasks/Milestones

| Task | Quarter | | | | | | | | | | | | | | | |
|--------------------------------------|---------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Component design and modeling | | | | | | | | | | | | | | | | |
| Sorbent development | | | | | | | | | | | | | | | | |
| Catalyst development | | | | | | | | | | | | | | | | |
| Microcombustor/-vaporizer developmt. | | | | | | | | | | | | | | | | |
| Microchannel system development | | | | | | | | | | | | | | | | |
| Component evaluations | | | | | | | | | | | | | | | | |
| 1 kW Fuel processor design /modeling | | | | | | | | | | | | | | | | |
| 1 kW Fuel processor fabrication | | | | | | | | | | | | | | | | |
| 1 kW Fuel processor evaluation | | | | | | | | | | | | | | | | |
| 25 kW Fuel processor design | | | | | | | | | | | | | | | | |
| 25 kW Fuel processor fabrication | | | | | | | | | | | | | | | | |
| 25 kW Fuel processor evaluation | | | | | | | | | | | | | | | | |
| Cost Analysis | | | | | | | | | | | | | | | | |



If We Are Successful: 50 kW Fuel Processor

| Component | Weights (kg) | Current | Reduction Goal | Proposed Prototype | Comment |
|--------------------------|--------------|---------|----------------|--------------------|------------------------------------|
| Fuel pump | | 2.27 | 50% | 1.14 | capillary action in microcombustor |
| Desulfurizer | | 12.10 | 35% | 7.87 | higher capacity liquid sorbents |
| Water tank | | 18.14 | 50% | 9.07 | better integration |
| Water pump | | 4.54 | 50% | 2.27 | capillary action in microcombustor |
| Fuel/water preheater | | 12.82 | 90% | 1.28 | microcombustor/microvaporizer |
| Reformer heat | | 22.00 | 90% | 2.20 | better thermal integration |
| Reformer | | 14.48 | 67% | 4.78 | better catalysts/microreactors |
| Shift reactors | | 59.40 | 67% | 19.80 | better catalysts/microreactors |
| Intercooler | | 11.34 | 90% | 1.13 | better thermal integration |
| Air compressor* | | 3.00 | 0% | 3.00 | |
| Preferential oxidizer | | 16.50 | 67% | 5.50 | better catalysts/microreactors |
| Fuel cell air cooler | | 11.34 | 90% | 1.13 | better thermal integration |
| Fuel cell exhaust drier | | 1.13 | 50% | 0.57 | |
| Burner | | 17.00 | 50% | 8.50 | microcombustor/microvaporizer |
| Thermal insulation | | 4.54 | 50% | 2.27 | better thermal integration |
| Valves | | 1.42 | 0% | 1.42 | |
| Starter Battery | | 1.10 | 0% | 1.10 | |
| Instrumentation/controls | | 11.34 | 50% | 5.67 | novel strategies/sensors |
| Sub-total | | 224.5 | | 78.7 | |
| Component integration | | | 10% | -7.87 | |
| Total | | 224.5 | | 70.8 | Specific energy of 706 W/kg |



Collaborators

Chemical Engineering: Erdogan Gulari (PrOx)
Phillip Savage (reactor design)
Johannes Schwank (ATR)
Ralph Yang (Sorption)

Mechanical Engineering: Dennis Assanis (Automobile modelling)
Jun Ni (Microdrilling/milling)

Aerospace Engineering: Werner Dahm (Microcombustor/-vaporizer)
Kenneth Powell (CFD)

Technology Transfer: Timothy Faley

Subcontractors: Hydrogen Burner (Root Wood)
MesoSystems (Charles Call)
Ricardo (Gordon Hensley)

Informal: Pacific Northwest National Laboratory
International Fuel Cell

